

The hunter-flies of Armenia

I. Some species of the genus *Limnophora* Robineau-Desvoidy, with the description of a new species

(Insecta, Diptera: Muscidae)

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Abstract. New field observations on adult behaviour and predation in *Limnophora riparia* (Fallén) and *Limnophora patellifera* (Villeneuve) in Armenia are given. The adults of the little-known *L. patellifera*, and a new species, *Limnophora femoriseta* sp. n. from Armenia and Turkey, are described. All three species discussed here are new records for Armenia.

Key words. Hunter-flies, Muscidae, *Limnophora*, Armenia, Turkey, predation.

Introduction

Species of the subfamily Coenosiinae of the family Muscidae are known as hunter-flies, or sometimes killer-flies, because of their activities as aggressive and effective predators of other small insects, in particular of blackflies (Simuliidae), mosquitoes (Culicidae), and a variety of garden and greenhouse pests (aphids, white flies, Agromyzidae, Chloropidae). The subfamily is divided into two tribes, the Coenosiini and the Limnophorini. A general review of predation by species of the Limnophorini has been given by WERNER & PONT (2006a), and the present paper offers some new observations on courtship and predatory behaviour and also describes a new species of the genus *Limnophora* Robineau-Desvoidy, 1830 from Armenia and Turkey.

The genus *Limnophora* contains some 350 species worldwide and is found in all zoogeographic regions, though poorly developed in North America and absent from New Zealand. The vast majority of species are associated with aquatic habitats and are predaceous in the adult and larval stages (WERNER & PONT 2006a).

The genus has been conventionally divided into three groups on the basis of the Palaearctic fauna, which in the past have sometimes been treated as subgenera or even as genera: *Calliophrys* Kowarz, 1893, *Pseudolimnophora* Strobl, 1893, and *Limnophora* s. str. The species of the *Calliophrys* group are associated with fast-flowing streams and torrents: adults rest on and hunt from stones and boulders in or alongside the water, whilst larvae are fully aquatic and live among mosses and other dense submerged vegetation. The European *L. riparia* (Fallén) is well known as a predator of Simuliidae (WERNER & PONT 2003).

During fieldwork in Armenia in 2005, and more recently in Turkey and Armenia in 2010, we collected several species of the *Calliophrys* group, and here we are describing one new species, *L. femoriseta* and are redescribing the little known species *L. patellifera* (Villeneuve). Because of the dominant presence of these flies in riverine habitats and their feeding

strategies, they play an important role as predators of black flies (Diptera: Simuliidae) and other aquatic and/or semiaquatic species, for example of *Chironomus* species (Diptera: Chironomidae) (WERNER & PONT 2006a). All three species of *Limnophora* discussed here are new records for Armenia.

Material and methods

The material discussed here was collected in Armenia in 2005 by ACP and DW, in Armenia in 2010 by ACP, and in Turkey in 2010 by NV. The adult flies were collected individually with a hand net, mostly on stones and rocks, and are deposited in the following collections: BMNH: The Natural History Museum, London, U.K.; – DW: Private collection of Doreen WERNER, Schöneiche, Germany; – IRSNB: Institut Royal des Sciences Naturelles de Belgique, Brussels, Belgium; – OUMNH: Oxford University Museum of Natural History, Oxford, U.K.; ZMHU: Museum für Naturkunde, Humboldt-Universität zu Berlin, Berlin, Germany; – ZMUM: Zoological Museum of the Lomonosov State University, Moscow, Russia.

To avoid repetition of authors' names, the following is a list of the species of Simuliidae that were collected in Armenia as prey of *Limnophora* species: *Simulium caucasicum* Rubtsov, 1940, *S. debaculi* Terteryan, 1952, *S. equinum* (Linnaeus, 1758), *S. lineatum* (Meigen, 1804), *S. paraequinum* Puri, 1933, *S. popowae* Rubtsov, 1940, *S. pseudequinum* Séguy, 1921, *S. variegatum* Meigen, 1818.

Geographic coordinates and altitudes in Armenia were taken with a Garmin eTrex navigator, and the presentation of all coordinates has been put into a standardised format.

Key to Armenian species of the *Calliophrys* group of *Limnophora*

- 1 Frons broadening gradually from vertex to lunula. Frontal triangle conspicuous, silvery-white, and long, reaching lunula. Vibrissal area with a conspicuous broad black patch [♂: mid femur with only a few short posteroventral setae in basal half, without anteroventrals; fore tarsus developed normally, not elongated] *riparia* (Fallén)
- Frons hardly broadening from vertex to lunula. Frontal triangle brown, inconspicuous, not always reaching lunula. Vibrissal area without a black patch, though sometimes darkened around the vibrissal setae 2
- 2 Hind tibia without an anteroventral seta. Parafacial when viewed from in front silvery-white pruinose. In lateral view, vibrissal angle projecting beyond level of profrons (Fig. 2). Fore tibia without posteroventral or ventral apical setae in ♂, the posteroventral present but short in ♀. ♂: mid femur (Fig. 5) with 4-5 anteroventral setae in basal half, slightly longer than femoral depth, and a row of longer posteroventral setae on all but apical quarter, decreasing in length apicad; fore tarsus normal, not elongated *femoriseta* sp. n.
- Hind tibia with 1 anteroventral seta. Parafacial when viewed from in front matt, dark, not shining, grey in ♀. In lateral view, vibrissal angle behind level of profrons (Fig. 1). Fore tibia with the posteroventral and ventral apical setae well-developed, as long as or longer than tibial depth (Fig. 4). ♂: fore tarsus (Fig. 3) enormously elongated, almost or quite twice as long as fore tibia, tarsomeres 1-4 very compressed and thin, tarsomere 5 flattened and expanded plate-like; mid femur without anteroventral setae, with 3-4 posteroventral setae in basal quarter, equal to femoral depth *patellifera* (Villeneuve)

Notes and descriptions of the species

Limnophora riparia (Fallén, 1824)

Material: ARMENIA: Gegharkunik: River Argichi at Nerkin Getashen, 40°08.54N, 45°16.04E, 1938 m, 9.vi.2005 (A. C. PONT), 4♂ 1♀ (BMNH); River Getik between Getik and Tujur, 40°40.33N, 45°13.01E, 1456 m, 22.vi.2010 (A. C. PONT), 1♂ (BMNH). Vayots Dzor: River Arpa east of Areni, 39°43.93N, 45°12.26E, 1024 m, 7.vi.2005 (A. C. PONT), 1♂ 1♀ (BMNH); stream below Noravank church, 39°40.94N, 45°14.13E, 1464 m, 15.vi.2010 (A. C. PONT), 6♂ (BMNH); the same, 24.vi.2010, 1♀ (BMNH). – ARMENIA, new predation records: Aragatsotn: River Apnaget at Apnagyugh Village, 40°26.31N, 44°23.40E, 1807 m, 12.vi.2005, 1♂ on *Simulium caucasicum* larvae (no. 2005/108) and 1♀ on *S. caucasicum* larvae (no. 2005/109 (D.WERNER) (DW). Gegharkunik: tributary of River Argichi at Nerkin Getashen, 40°08.51N, 45°16.036E, 1938 m, 9.vi.2005, 1♂ on *Micrasema bifoliatum* Martynov, 1925 (Trichoptera) (no. 2005/59), 1♀ on *S. caucasicum* pupae (no. 2005/64), and 1♀ on *S. caucasicum* larvae (no. 2005/66) (D.WERNER) (DW).

Limnophora riparia is a widespread European species, distributed throughout the whole Palaearctic region including North Africa (see PONT 2010) and here recorded for the first time from Armenia.

The species has so far been found only in the vicinity of fast-flowing streams, brooks or rivers. The adults tend to rest on stones lying in the water and on river banks on stones, dead plant material, wooden posts, bunes or bridges constructed from concrete and on railings, always close to the water surface. When the sun is shining and the temperature exceeds 12°C, adults are very active and can often be observed in the splash zone on rocks in the water. They run around on the substrates, searching for food or for other flies with which to copulate. If the temperature is higher than 34°C and their searching area is fully in the sun, adults tend to rest in shaded areas and wait for lower temperatures or for higher humidity before becoming active again with hunting and reproductive activities.

Limnophora riparia is the most important predator of blackfly larvae and adults in many habitats. Because of its adaptations to the occurrence of simuliid and chironomid populations in Armenia, we were able to clarify some of its ecological requirements as well as its hunting, mating and egg-laying strategies. The strategies of different *Limnophora riparia* populations are comparable in their behaviour and in each habitat. A detailed description of the general occurrence and territoriality of *L. riparia* in the Palaearctic region has been given by WERNER & PONT (2006a).

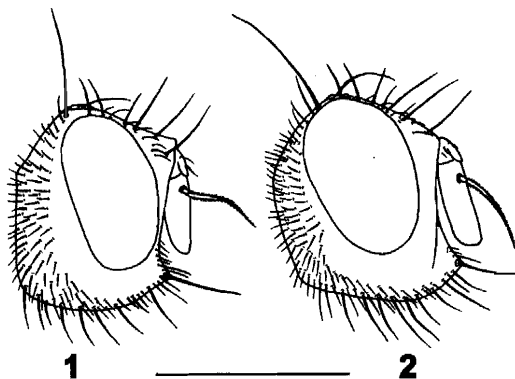
No specific territoriality was observed at the sampling sites in Armenia. The flies are usually observed singly on stones or on mosses or algae but sometimes a few individuals are present together. The males and females move around on the substrates, sometimes touching each other with their legs, attempting copulation, and then moving away. When a male moves or runs around on the surface and meets a female, the female stops moving and the male tries to face or recognise her for a moment. He then starts the “dancing ceremony”, which is the typical dancing behaviour performed in semicircles and/or circles around the female. The courtship dance is very similar to what we have observed in *L. riparia* all over Europe (WERNER & PONT 2006a). The male always focuses on the female and walks sideways like a crab, moving the legs very fast and changing direction in an indefinite rhythm. He repeats the semicircles 10 times or more and pauses from time to time at various points. Whilst dancing, the male moves his head up and down and the reflected sunlight from his frons and antennae probably functions as a visual signal. The female also focuses on the male who is dancing around her. If she is “ready” to copulate, she lowers her position so that she is flatter against the substrate, and the male touches her on the wings with his fore legs,

or sometimes on the head or the body, which is his first direct contact with her. He moves the end of his abdomen round and begins copulation. If the couple is interrupted before copulation, they both fly away. When they have been copulating for a few seconds, they are easily collected as they appear to be less wary. The complete copulatory process is not often seen, and unsuccessful attempts at copulation are more usually the case. In Armenia, we were fortunate enough to be able to observe copulation but we also needed to collect the pairs in order to identify the species. For just a very few couples (4), the complete dancing ceremony was observed. The precopulatory behaviour with touching and circular dancing takes some minutes, and the true dance, as described above, is easy to recognise. Courtship and mating never take place while resting in shade or on plants. It seems that the adults always need a platform on which to perform their dance. In some habitats up to forty individuals could be found per square metre, resting on river bank vegetation and waiting for better weather conditions.

Adults can also often be found in the splash zone where their prey can be captured. Adults, both males and females, run up and down whilst searching for food. As we know from earlier studies, they feed on chironomids, other Diptera, and smaller insects, and they are potentially important predators of simuliid larvae. They touch a larva with their fore legs and pull it out of the water and into a sheltered spot, where they begin to feed by piercing the larval skin and inserting their mouthparts. In Armenia we were able to observe the species for the first time also feeding on pupae. For further details and a description of the habitat, see the notes under *L. patellifera*. In slow-running habitats in Armenia, there is often a layer of algae and moss covering the river bank.

Limnophora patellifera (Villeneuve, 1911) (Figs 1, 3-4, 7-9, 13-14)

Material: ARMENIA: Gegharkunik: River Argichi at Nerkin Getashen, 40°08.54N, 45°16.04E, 1938 m, 9.vi.2005 (A. C. PONT, D.WERNER), 3♂ (2 BMNH, 1 ZMHU); tributary of River Argichi at Nerkin Getashen, 40°08.53N, 45°15.31E, 1932 m, 9.vi.2005 (D.WERNER), 1♂, 1♀ (BMNH); River Getik between Getik and Ttujur, 40°40.33N, 45°13.01E, 1456 m, 22.vi.2010 (A. C. PONT), 1♂ 1♀ (BMNH). Vayots Dzor: tributary of River Arpa, 39°41.58N, 45°31.32E, 1467 m, 15.vi.2010 (A. C. PONT), 1♂ (BMNH); stream below Noravank church, 39°40.92N, 45°14.11E, 1477 m, 7.vi.2005 (A. C. PONT & D.WERNER), 2♀ (BMNH & ZMHU); stream below Noravank church, 39°40.94N, 45°14.13E, 1464 m, 15.vi.2010 (A. C. PONT), 2♂ (BMNH & ZMUM); the same, 24.vi.2010, 2♂ (BMNH), 1♀ (ZMUM). – TURKEY: Mersin province, near Silifke, 36°40'5N, 33°80'4E, forest stream, 23.iv.2010 (N.VIKHREV), 1♂ (ZMUM); Antalia province, Kopru River, 37°07'5N, 31°23'2E, 10.ix.2009 (N.VIKHREV), 5♀ (ZMUM). – TURKMENISTAN: Geok-Tepe suburbs, Chuli near Babarab, reared from larvae, v.1984 (M.KRIVOSHEINA), 3♂, 4♀, of which 1♂ & 2♀ in ZMUM (see LOBANOV, 1988: 200). – TAJIKISTAN: Dushanbe div., Varzob environs, 38°89'N, 68°82'E, 30.v.2010 (K.TOMKOVICH), 1♀ (ZMUM). – ARMENIA, new predation records: Gegharkunik: River Argichi at Nerkin Getashen, 40°08.54N, 45°16.03E, 1938 m, 9.vi.2005 (D.WERNER), 1♀ on *Simulium* (*Wilhelmia*) larva, probably *S. pseudequinum* (no. 2005/56) (DW); same locality and date, 40°08.51N, 45°16.04E, 2♂ on *S. caucasicum* pupae (nos. 2005/61 and 2005/67) (DW); same locality and date, 40°08.51N, 45°16.04E, 4♀ on *S. caucasicum* pupae (nos. 2005/60, 2005/62, 2005/63, 2005/65) (DW); same locality and date, 40°08.53N, 45°15.31E, 1932 m, 1♂ on *S. debaculi* larva (no. 2005/75) (DW). Kotayk: River Hrazdan north of Arzni, 40°19.15N, 44°35.16E, 1269 m, 8.vi.2005 (D.WERNER), 1♂ on *S. variegatum* larva (no. 2005/52), 2♀ on *S. caucasicum* larvae (nos. 2005/47 and 2005/50), 1♀ on *S. (Wilhelmia)* larva, probably *S. paraequinum* (no. 2005/48), 1♀ on *S. equinum* larva (no. 2005/51), and 1♀ with *S. variegatum* larva (no. 2005/53) (DW); Azat River canyon, Garni N.P., 40°06.50N, 44°42.75E, 1206 m,



Figs 1-2. ♂ head in lateral view of: 1- *Limnophora patellifera* (Villeneuve); 2- *Limnophora femoriseta* sp. n. Scale-bar 1 mm.

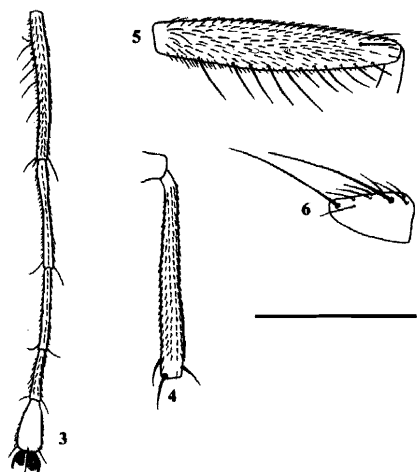
4.vi.2005 (D.WERNER), ♂, ♀, on *S. popowae* larvae (no. 39/2005) (DW) (see WERNER & PONT, 2006b: 134, fig. 1). Vayots Dzor: River Arpa east of Areni, 39°43.93N, 45°12.26E, 1024 m, 7.vi.2005 (D.WERNER), 1♂ on *S. variegatum* male (no. 2005/55) (DW).

This little-known species was previously known only from the holotype (VILLENEUVE 1911) and from the few specimens listed above from Turkmenistan (LOBANOV 1988). LOBANOV gave a description of both sexes in Russian and also illustrated the larval mouth-parts. We give here a redescription in English, based on our material.

Description of male

Head (Fig. 1): Ground-colour black. Eye bare. Frons broad, at level of anterior ocellus 0.36-0.38 of head-width at this point, more or less parallel-sided from vertex to lunula. Ocellar strong, slightly shorter than the inner vertical; outer vertical hardly distinct from the adjacent post-ocular setulae. Fronto-orbital plate wholly dark brown pruinose even when viewed from above. Parafacial dark when viewed from in front, dull, matt, without trace of silvery-white pruinosity. Ocellar triangle indistinct, brown dusted, only visible from certain angles and reaching a little over halfway from anterior ocellus to lunule. Frontal vitta dark, matt, brown when viewed from below. Face grey pruinose, occiput greyish-white, tinged with brown above; gena with a conspicuous, silvery-white pruinose patch below lower anterior eye-angle. At middle of frons, a fronto-orbital plate 0.17-0.22 width of frontal vitta. 3-4 pairs of inclinate frontal setae, with a few interspersed setulae, and 2 pairs of reclinate orbital setae, with several short setulae outside them on fronto-orbital plate. Antenna black; postpedicel 2.5-2.7 times as long as wide and falling short of mouth margin by its own width, smoothly rounded at tip. Arista short-pubescent, the longest individual hairs hardly as long as its basal width. Parafacial narrow, at middle 0.5-0.6 as wide as width of postpedicel, bare. In lateral view, mouth-edge behind level of profrons (Fig. 1). Facial ridge with several short setulae above vibrissa. Depth below lowest eye-margin 0.4 of length of postpedicel. Genal setae fine. Palpus black, slender. Prementum of proboscis glossy, black.

Thorax. Ground-colour black. Scutum dark brown dusted with paler dusted areas as follows: whitish-grey, almost bluish, dust along neck; grey dust on prostpronotal lobe, notopleuron and postalar callus; a pair of presutural yellowish-white patches on suture, between presutural supraalar and dorsocentral rows and extending inconspicuously forward along

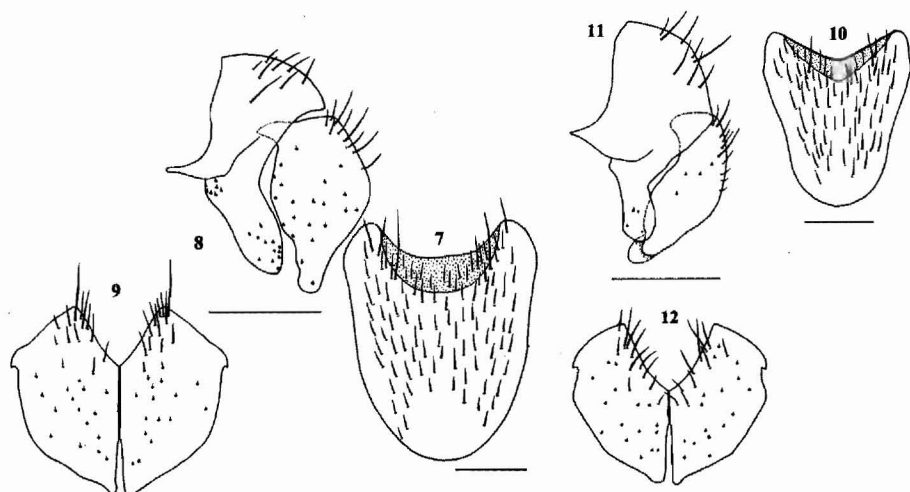


Figs 3-6. 3- *Limnophora patellifera* (Villeneuve), ♂ fore tarsus, dorsal view; 4- *Limnophora patellifera* (Villeneuve), ♂ fore tibia, lateral view; 5- *Limnophora femoriseta* sp. n., ♂ mid femur, posterior view (holotype); 6- *Limnophora femoriseta* sp. n., scutellum, lateral view (holotype). Scale-bar 1 mm.

dorsocentral lines as far as neck; after suture with a pair of greyish vittae on each side, running along the dorsocentral and supraalar rows and coalescing in front of postalar callus but not quite meeting medially. Pleura almost wholly whitish-grey, almost bluish, dusted. Prothoracic spiracle dirty whitish. Scutellum mostly grey, with an elongate dark brown spot on each side around sub-basal lateral seta that extends weakly almost to the preapical setae. Acrostichals 0+1, the single (prescutellar) pair weak, the presutural setulae in 2 rows with 1-2 additional setulae between the rows at suture. Dorsocentrals 2+4. Proepimeral seta with 3-4 additional short setulae. Katepisternals 1+2, the lower one shorter than the upper two. Proepisternal depression, notopleuron (except for setae) and meron bare. Scutellum uniformly setulose on disc, with one setula outside the apical pair directed backwards and downwards (as in Fig. 6); lateral margins and ventral surface bare.

Legs. Black; coxae and femora whitish-grey, almost bluish, dusted. Fore femur with a complete row of uniform posteroventral setae about as long as femoral depth. Fore tibia without submedian setae; apical posteroventral seta strong, much longer than tibial depth, and with an almost equally long ventral apical seta (Fig. 4). Fore tarsus (Fig. 3) enormously elongated, almost or quite twice as long as fore tibia; tarsomeres 1-4 very compressed and thin, tarsomere 5 flattened and expanded plate-like; with 4-5 fine erect posteroventral hairs on tarsomere 1 and 1 such hair at the tip of tarsomeres 2-4, and also on anteroventral surface with a similar hair at tip of tarsomeres 1-3. Mid femur without anteroventral setae, with 3-4 posteroventral setae in basal quarter, equal to femoral depth; with several anterior setae in basal half; 0 anterior and 2, rarely 1, posterior preapical setae. Mid tibia with 1 posterior seta. Hind femur without ventral setae except for 2, rarely 3-4, anteroventrals in apical half. Hind tibia with 1 anterodorsal and 1 anteroventral seta; 1 dorsal preapical, anterodorsal preapical absent.

Wing. Long and narrow, slightly smoky. Basicosta and tegula black. Costal spine inconspicuous. Veins bare except for costa and a few setulae on and slightly beyond the node at the base of vein R_{4+5} . Crossvein r-m below or slightly beyond the point where vein R_1 enters



Figs 7-9. *Limnophora patellifera* (Villeneuve), ♂: 7- Sternite 5; 8- Hypopygium, lateral view; 9- Cercal plate. Scale-bars 0.25 mm. (Gegharkunik, tributary of River Argichi at Nerkin Getashen, 40°08.53'N, 45°15.31'E, 1932 m, 9.vi.2005.). – Figs 10-12. *Limnophora femoriseta* sp. n., ♂: 10- Sternite 5; 11- Hypopygium, lateral view; 12- Cercal plate. Scale-bars 0.25 mm. (Paratype from Vayots Dzor, stream below Noravank church, 39°40.92'N, 45°14.11'E.).

costa. Crossvein dm-cu weakly sinuous to almost straight. Veins R_{4+5} and M_1 parallel at wing-margin. Calypters white, margins creamy. Haltere yellow.

Abdomen. Ground-colour black. With whitish-grey dust that becomes almost bluish on sides and ventral surface of abdomen, including sternites, pregenital tergites and epandrium, and with dark brown to black markings as follows: tergites 3 and 4 each with a pair of large, bold, well-defined, subquadrate spots, reaching from fore- to hind-margin and extending to lateral edge of each tergite, narrowly separated medially by dust; syntergite 1+2 with similar but smaller spots; tergite 5 with a weaker, less well defined, median, triangular brown patch, also reaching from fore- to hind-margin. Tergites without strong setae, with a few lateral marginals on tergite 4 and a marginal row on tergite 5. Sternite 1 bare, 2♂ with a fine setula on each side. Sternite 5 as in Fig. 7.

Terminalia. Figs 8-9.

Measurements. Length of body, 4.5 - 5.0 mm. Length of wing, 4.0 - 4.5 mm.

Description of female

Differs from the male as follows:

Head. Frons at level of anterior ocellus 0.39-0.44 of head-width at this point, broadening slightly from vertex to lunule. Outer vertical seta distinct, almost twice as long as one of the adjacent post-ocular setulae. Fronto-orbital plate dull grey pruinose, brown along inner margins and, usually, in upper part; face and parafacial dull grey. Ocellar triangle almost reaching lunule. Some brown dust around vibrissal angle and on facial ridge. At middle of frons a fronto-orbital plate 0.27-0.29 width of frontal vitta. Postpedicel 2.5-2.6 times as long as

wide. Parafacial at middle 0.8-0.9 times as wide as width of postpedicel. Depth below lowest eye-margin 0.5-0.6 of length of postpedicel.

Thorax. Scutum as in ♂, but without the thin band of whitish-grey dust along neck, sometimes the paler vittae yellowish-grey, sometimes much lighter grey. Scutellar spots sometimes extending from base only to the sub-basal seta, sometimes almost reaching apical seta. Prothoracic spiracle brownish. Presutural acrostichal setulae strictly 2-serial. 1♀ with 3 postsutural dorsocentrals.

Legs. Fore tarsus not modified; fore tarsus 1.2-1.3 times as long as fore tibia; tarsomere 1 with 3-5 posteroventral hairs, one at the tip of tarsomere 2, and a short one on tarsomere 3, but none on tarsomere 4. Mid femur with the posteroventral setae present but weaker. Hind femur usually with only the 2 anteroventrals just before apex.

Wing. Setulae on vein R_{4+5} confined to the node at base.

Abdomen. Markings as in ♂, but spots on syntergite 1+2 not reaching fore-margin, and the median patch on tergite 5 reduced to a median vitta or sometimes absent. Setae weak. Sternite 1 without (8♀) or with (5♀) a fine setula on each side.

Ovipositor. Not examined.

Measurements. Length of body, 4.5-5.5 mm. Length of wing, 4.5-5.5 mm.

There is some variation in the length of the posteroventral and ventral apical setae on fore tibia. The species is also slightly variable in appearance: the dusting on the scutum is usually weakly yellowish-grey, so that there is little contrast between the dusted markings and the dark brown background. Some specimens however have the dusted markings much greyer and lighter, and there is thus considerable contrast between these markings and the background. However, the arrangement of the markings is constant, and this seems to be no more than infra-specific variation, perhaps reflecting the age of specimen.

This species was described from a single male from Syria, Damas [= Damascus]. The holotype in IRSNB, which is in good condition, was examined by the senior author. The species was unknown to HENNIG (1955-1964) when he wrote his monograph on the Palaearctic Muscidae, and also to PONT (1991: 97) when he summarised records of Muscidae from Turkey and the Middle East. LOBANOV (1988: 199) recorded it from Turkmenistan, from 3♂ 4♀ collected at Chuli near Babarab; he gave a redescription in Russian of the adult ♂ and ♀ together with illustrations of the genitalia and of the 3rd instar larval mouth-parts, but had no information on the biology or behaviour of the species. This is the first record of this species from Armenia.

Limnophora patellifera is a little-known species but is one of the dominant *Limnophora*-species in Armenia according to our fieldwork. No information has been published about its habitat requirements and biology, but our observations in Armenia have enabled us to describe some aspects of the courtship behaviour, hunting strategies and feeding patterns in relation to the larval, pupal and adult stages of blackfly species. During our observations it became clear that the species is a most effective predator of several pest species of *Simulium*, mostly members of the subgenus *Wilhelmia* such as *S. equinum*, *S. lineatum*, *S. pseudequinum* and *S. paraequinum*, and others such as *S. caucasicum* and *S. variegatum* (WERNER & PONT 2006b). Our observations in Armenia have now given us a total of 15 comparable strategies by hunting adults, have extended the prey spectrum on Simuliidae to include *S. pseudequinum*, *S. debaculi* and *S. popowae*, and have given support in many cases to the suggested modes of feeding.

The observations described below refer principally to *Limnophora patellifera*, but at several localities and breeding sites the species was present together with *L. riparia*. Females of these species are difficult to distinguish whilst alive in the field, but the behaviour of the two species appears to be very similar.

Behaviour

Courtship and mating. Observations on mate recognition and courtship by *Limnophora patellifera* were made on sunlit rocks in the water or on the river banks. No specific territorial behaviour was observed. The adult flies may be very common on rocks located in the river bed. They move around on the surface of the rocks and often come into quick contact with each other. Often they just recognise each other visually, but sometimes they touch legs or bodies and move away after this contact. In some cases the flies meet and come into contact for a few fractions of a second whilst they cross paths and circle around each other and then continue on their way as if nothing had happened, without looking at or taking any notice of the other fly. Such behaviour has also been observed in *Limnophora riparia* and species of *Lispe*. We do not know whether this is connected with copulatory or territorial behaviour or is even a quick exploratory investigation for possible copulation. As in all other *Limnophora* species, the adults are very active and their movements are like a dance. They are always active, searching for food or some liquid to imbibe. When they find some, they stop and suck for a short time whilst continuously moving their proboscis up and down. When finished, they do not rest but immediately start walking around along the stones again. When a male and a female meet and are "interested" in each other, the female stops moving and the male tries to face her and to gain her attention. He then also displays a kind of "dancing ceremony", which is the typical dancing behaviour exhibited by species of this group of *Limnophora*: he makes a series of more or less repeated crab-like movements in a semicircle around the female. This dance is strongly reminiscent of the "dancing ceremony" of *L. riparia*, for which a detailed description is given in WERNER & PONT (2006a). Unlike the precopulatory behaviour of *L. riparia*, we never observed a male dancing in a full circle around the female. When dancing, the male moves his head up and down, thereby producing what is probably a visual signal from the sunlight reflecting from his frons and antennae. The female also focuses on the male who is dancing around her. The male is very active and focuses only on her, and if she is willing to copulate then she flattens herself a little against the substrate whereupon the male will make the first direct contact with her by touching her with his fore legs on the wings or sometimes on the head or the body. After that, he moves the end of his abdomen round and begins copulation when he is in contact with her body. There are elements here which are very similar to the strategy and rhythms of *L. riparia* and *L. exuta* (Kowarz), and so we believe that some if not all the species of the *Calliophrys*-group of *Limnophora* will be found to have a similar courtship and mating behaviour.

Oviposition. Another similarity between *L. patellifera* and *L. riparia* in Armenia is in the mode of oviposition. We were able to observe a female of *L. patellifera* on 8.vi.2005 in the Kotayk region: River Hrazdan north of Arzni (40°19.15N, 44°35.16E), at 1269 m. The locality was in the bed of the River Hrazdan. The rocks in the water were exposed to the sun and offered the flies an ideal place for resting and mating. Because of the turbulence of the river, the level of the water swirling around these rocks was fluctuating up and down. The north-east and south sides of the rocks were covered with carpets of mosses and algae, which were colonised by numerous other Diptera (Clinocerinae, Simuliidae and Chironomidae).

A female was observed ovipositing in this carpet of moss and algae at around midday. At this time the rock was in direct sunlight and its surface temperature was 42°C. The female was running around the rock in the immediate vicinity of the fluctuating water level and attracted our attention by her “searching” behaviour. When she reached a small indentation in the rock, she crawled in and inspected the algal matt. She was very wary and was disturbed by the slightest vibration or movement of the shadows. She tested the substrate with her fore legs and probed a spot among the wet mosses and algae many times with her abdomen. Finally she laid her eggs right into the substrate, with her fore legs directed upwards and her abdomen pushed into the wet substrate. As in *L. riparia*, it took between 20 and 30 seconds to lay one egg. The first egg projected above the algal surface by about 2/3 of its length. The second and third eggs were laid next to the first one, so that small clusters of eggs were produced even though each egg was laid singly. A different approach was followed as further eggs were laid. Most were laid singly in the substrate, whilst some others (three formations) were laid in clusters of 2-3 eggs. All the eggs projected from the substrate by some 2/3 of their total volume, and could be easily seen on account of their whitish colour. As we wanted to determine the species of this female, she was caught after about 15 minutes. The entire patch of algae was taken for analysis, and we found it to contain a total of 21 eggs. The first larvae hatched after 2.5 to 3 days at an average temperature of 25°C.

Larval habitat. According to Marina KRIVOSHEINA (emails of 23 & 24 January 2010), who collected the material in Turkmenistan reported by LOBANOV (1988), the larvae were found in a small but rapid mountain river, 2-4 m in width and no more than 1 m deep. They were living among bushy aquatic plants and algae growing on the river bottom and in the middle of the river where the current was strongest, at a depth of 5-15 cm. Larvae collected at the beginning of May pupariated quickly, and adults emerged from the end of May to the beginning of June.

Hunting. At certain localities, the preimaginal stages of *Simulium popowae*, principally pupae but also isolated larvae, were abundant in the river splash zone. In such places the flies could wander freely and unhindered, and could select an appropriate prey. Their movements are very rapid and they skilfully avoid the drops of water. When a larva has been selected as a potential prey, the flies will attack it until it is profoundly disturbed. We observed how larger larvae, using their silken threads, release their hold and drop into the water, thereby escaping the attack. The flies continuously attack the larvae. When a larva defends itself by curling or stretching out its body, the fly skilfully avoids these jerky movements but may eventually give up this attack. After a while, weak larvae and also younger, smaller larvae are rolled by a fly directly into a more splash-free area of the rock by using its fore legs. It is only here that the fly begins to suck the larval prey. There are generally several flies on the rock which are already lined up and ready to attack the larva and which then join together to suck. Unlike other *Limnophora*-species, which usually pierce behind the sclerotised head-capsule of the larva, the adults of *L. patellifera* pierce the soft body of the larva at all points and suck the larva dry.

In Gegharkunik province, at a tributary of the Armenian River Argichi at Nerkin Getashen (40°08.51N, 45°16.04E), 1938 m, we were able to observe on 9 June 2005 a female of *L. riparia* (no. 2005/64), which was feeding on *Simulium caucasicum* pupae, and 2 males and 4 females of *L. patellifera* (nos 2005/60, 2005/61, 2005/62, 2005/63, 2005/65, 2005/67) which were also feeding, i.e. sucking, pupae of *S. caucasicum*. At this point the water level of the stream could be regulated, and the adjacent water plants and a drainage pipe that ran



Figs 13-14. *Limnophora patellifera* (Villeneuve). 13- Male and female attacking a larva of *Simulium popowae* (Rubtsov), at the breeding site in Kotayk, Azat River canyon, Garni N.P., 40°06.49N, 44°42.76E; 14- Male feeding on a larva of *Simulium popowae* (Rubtsov), at the breeding site in Kotayk: Azat River canyon, Garni N.P., 40°06.49N, 44°42.76E. Photographs: Doreen WERNER.

along the length of the stream were coated with a dense layer of several rows of simuliid pupae, because the water level had probably been lowered the previous day and had exposed

them to the air. Many pupae had already emerged or were on the point of emerging, but some fresh simuliid pupae were attacked and sucked by the *Limnophora*.

In addition to these observations on predation of simuliid larvae and pupae, a male of *L. patellifera* was observed on 7 June 2005 (River Arpa east of Areni, 39°43.93N, 45°12.26E) sucking a male of *Simulium variegatum*.

***Limnophora femoriseta* sp. n.** ♂ ♀ (Figs 2, 5-6, 10-12)

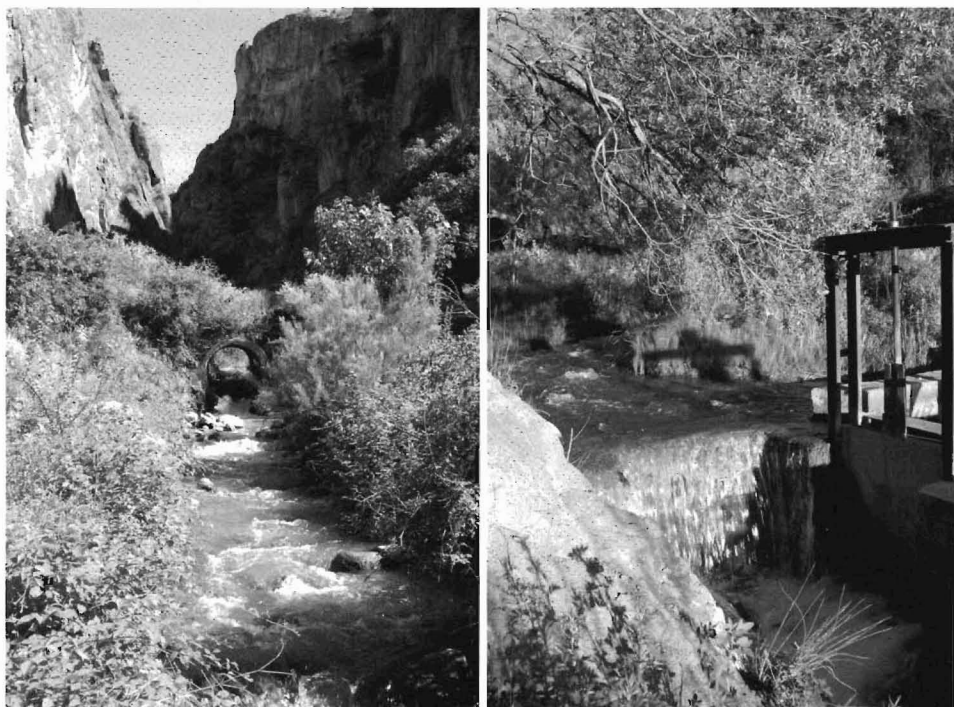
Material: Holotype ♂, ARMENIA, Vayots Dzor: stream below Noravank church, 39°40.92N, 45°14.11E, 1477 m, 7.vi.2005 (A. C. PONT & D. WERNER) (BMNH). – Paratypes 29♂ 35♀. ARMENIA: same data as holotype, 1♂ (ZMHU), 2♂ 2♀ (BMNH); stream below Noravank church, 39°40.94N, 45°14.13E, 1464 m, 15.vi.2010 (A. C. PONT), 3♂ (2 BMNH, 1 OUMNH); the same, 24.vi.2010, 2♂ 4♀ (BMNH, 1♀ OUMNH). Aragatsotn: River Amberd at Byurakan, 40°20.95N, 44°16.09E, 1565 m, 25.vi.2010 (A. C. PONT), 1♂ 3♀ (BMNH). Kotayk: Azat River canyon, Garni N.P., 40°06.49N, 44°42.75E, 1206 m, 4.vi.2005 (A. C. PONT), 1♀ (BMNH); Garni Canyon, 40°06.88N, 44°44.48E, 1277 m, 14.vi.2010 (A. C. PONT), 1♀ (BMNH). TURKEY: Antalya province, Köprü River, 37°075N, 31°232E, 9-10.ix.2009 (N. VIKHREV), 2♂ 7♀ (ZMUM); Mersin province, near Silifke, 36°405N, 33°804E, forest stream, 23.iv.2010 (N. VIKHREV), 18♂ 17♀ (ZMUM).

Etymology. The species name refers to the long posteroventral *setae* on the male mid *femur*.

Description of male

Head (Fig. 2): Ground-colour black. Eye bare. Frons broad, at level of anterior ocellus 0.35-0.40 of head-width at this point, narrowing from vertex to lunula. Ocellar strong, slightly shorter than the inner vertical which is 3 times as long as the outer vertical, which is not much longer than the adjacent post-ocular setulae. Fronto-orbital plate when viewed from in front brown pruinose for most of its length, darker above, merging below with the silvery-white parafacial, more yellowish-white when viewed from above. Ocellar triangle indistinct, brown dusted, only visible from certain angles and appearing cut-off, not reaching halfway from anterior ocellus to lunule. Frontal vitta matt, brownish-yellow when viewed from below. Face, gena and most of occiput silvery-white pruinose, gena with a large patch below lower anterior eye-angle more conspicuously silvery pruinose. At middle of frons, a fronto-orbital plate 0.2 width of frontal vitta. 3-4 pairs of inclinate frontal and 2 pairs of reclinate orbital setae, with a few short setulae outside them on fronto-orbital plate. Antenna black; postpedicel 3.7 times as long as wide and falling short of mouth margin by its own width, smoothly rounded at tip. Arista short-pubescent, the longest individual hairs hardly as long as its basal width. Parafacial broad, at middle 1.2-1.3 as wide as width of postpedicel, bare. In lateral view, mouth-edge reaching further forward than profrons (Fig. 2). Facial ridge with few short setulae above vibrissa. Depth below lowest eye-margin 0.6 of length of postpedicel. Genal setae fine. Palpus black, slender. Prementum of proboscis glossy, black.

Thorax. Ground-colour black. Viewed from above, scutum dark brown dusted with whitish-grey, almost bluish, dust along neck, on prostpronotal lobes, notopleura and postalar calli; viewed from behind, with a pair of presutural brownish-white patches along suture, between presutural supraalar and dorsocentral rows and just touching posterior dorsocentral, and after suture with the light dust of the postalar calli extending mesad along scutellar suture but not quite meeting medially and then extending inconspicuously forwards inside the dorsocentral rows to 3rd dorsocentral or even slightly further. Pleura from most angles almost wholly whitish-grey, almost bluish, dusted. Prothoracic spiracle dirty whitish. Scutellum mostly



Figs 15-16. Type-locality of *Limnophora femoriseta* sp. n. at Vayots Dzor, stream below Noravank church, 39°40.92'N, 45°14.11'E; 15- Stream; 16- Side of the concrete tanks.

dark brown dusted, with a light grey median vitta reaching from base to tip and continuing below tip and some or all the way along the sides. Acrostichals 0+1, the single (prescutellar) pair weak, the presutural setulae in 2 rows with 1-2 additional setulae between the rows at suture. Dorsocentrals 2+4, the second postsutural pair weaker than the others. Postsutural intraalars short. Proepimeral seta with 2-3 additional short setulae. Katepisternals 1+2, the lower one shorter than the upper two. Proepisternal depression, notopleuron (except for setae) and meron bare. Scutellum uniformly setulose on disc, with one setula outside the apical pair directed backwards and downwards (Fig. 6); lateral margins and ventral surface bare.

Legs. Black; coxae and femora whitish-grey, almost bluish, dusted. Without modifications. Fore femur with a row of uniform posteroventral setae on basal 3/4, about 1.5 times as long as femoral depth, replaced in apical 1/4 by short setulae. Fore tibia without submedian setae; apical posteroventral seta vestigial. Fore tarsus 1.25 times as long as fore tibia; with 3-4 fine erect posteroventral hairs on tarsomere 1 and 1 such hair at the tip of tarsomeres 2-4, and also on anteroventral surface with a similar hair at tip of tarsomeres 1-3. Mid femur with 4-5 anteroventral setae in basal half, slightly longer than femoral depth, and a row of longer posteroventral setae on all but apical quarter, decreasing in length apicad (Fig. 5); with several anterior setae in basal half; 0 anterior and 2, rarely 1, posterior preapical setae. Mid tibia with 1 posterior seta. Hind femur without ventral setae except for 2 short anteroventrals

before apex. Hind tibia with 1 anterodorsal and 0 anteroventral (rarely 1) seta; 1 dorsal preapical, anterodorsal preapical absent.

Wing. Long and narrow, slightly smoky. Basicosta brown, tegula black. Costal spine inconspicuous. Veins bare except for costa and a few setulae on and slightly beyond the node at the base of vein R_{4+5} . Crossvein r-m below the point where vein R_1 enters costa. Crossvein dm-cu weakly sinuous to almost straight. Veins R_{4+5} and M_1 parallel at wing-margin. Calypsters white. Haltere yellow.

Abdomen. Ground-colour black. With whitish-grey dust that becomes almost bluish on sides and ventral surface of abdomen, including sternites, pregenital tergites and epandrium, and with dark brown to black markings as follows: tergites 3 and 4 each with a pair of large, bold, well-defined, subquadrate spots, reaching from fore- to hind-margin and extending to lateral edge of each tergite, narrowly separated medially by dust; syntergite 1+2 with similar but smaller spots; tergite 5 with a weaker, less well defined, median, triangular brown patch, also reaching from fore- to hind-margin. Tergites without strong setae, with a few lateral marginals on tergite 4 and a marginal row on tergite 5. Sternite 1 bare. Sternite 5 as in Fig. 10.

Terminalia. Figs 11-12.

Measurements. Length of body, 4.0 - 5.0 mm. Length of wing, 3.5 - 4.5 mm.

Description of female

Differs from the male as follows:

Head. Frons at level of anterior ocellus 0.41-0.46 of head-width at this point, broadening slightly from vertex to lunule. Ocellar triangle reaching lunula in 2♀, cut off as in male in 1♀. At middle of frons a fronto-orbital plate 0.14-0.2 width of frontal vitta. Postpedicel 3.3-3.7 times as long as wide and falling short of mouth margin by a little more than its own width. Parafacial at middle 1.2-1.3 times as wide as width of postpedicel. Depth below lowest eye-margin 0.6-0.8 of length of postpedicel.

Thorax. Scutum dark brown dusted, but with the paler dusting more extensive from all points-of-view: presuturally, with a brownish-grey median vitta, wider than the rows of acrostichal setulae, and a pair of brownish-grey vittae running through the dorsocentral rows and connecting with the pale spot at suture; postsuturally, with the median brownish-grey vitta continuing from suture to scutellum, flanked by a pair of light grey vittae running through the dorsocentral rows, becoming broader at level of 3rd dorsocentral, and a pair of broad vittae running through the intraalar setae that connect at scutellar suture with the dorsocentral vittae, these paler markings much weaker in 1♀. Scutellum light grey, sometimes almost bluish, dusted with a long brown spot surrounding the sub-basal lateral seta. Presutural acrostichal setulae strictly 2-serial. 2nd postsutural dorsocentral slightly stronger, but still weaker than the others. 3-4 proepimeral setulae.

Legs. Fore femur with the row of posteroventral setae complete, with several of the setae 1.5 times as long as femoral depth. Fore tibia with the posteroventral apical seta present, slightly shorter to slightly longer than tibial width at this point. Fore tarsus 1.1-1.2 times as long as fore tibia; tarsomere 1 with 3-5 posteroventral hairs, one at the tip of tarsomere 2, and a short one on tarsomere 3, but none on tarsomere 4. Mid femur without ventral setae or with 1-2 short anteroventral setae, posterior preapicals rarely 4. Hind tibia without an anteroventral seta.

Wing. Crossvein r-m slightly basad of the point where vein R_1 enters costa. Margin of upper calypter creamy, of lower calypter yellow.

Abdomen. Markings as in ♂, but spots on syntergite 1+2 not reaching fore-margin, and the median patch on tergite 5 reduced to a weak median vitta. Setae weak.

Ovipositor. Not examined.

Measurements. Length of body, 4.5 - 5.0 mm. Length of wing, 4.5 - 5.0 mm.

Distribution. Armenia and Turkey. The type-locality in the Armenian province of Vayots Dzor (the stream below Noravank church) is close to a well-known touristic and religious monument. At this point the stream is channelled into several concrete-lined tanks before continuing down the valley (Figs 15-16). In both 2005 and 2010, the specimens were collected in the early evening, flying around and resting on the walls of these tanks. No observations on courtship or predation were made.

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